(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 1 673 944 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
04.09.2019 Bulletin 2019/36

(21) Application number: **04794941.7**

(22) Date of filing: **12.10.2004**

(51) Int Cl.:
H04N 19/85 *(2014.01)*

(86) International application number:
PCT/US2004/033713

(87) International publication number:
WO 2005/039189 (28.04.2005 Gazette 2005/17)

(54) TECHNIQUE FOR BIT-ACCURATE FILM GRAIN SIMULATION

VERFAHREN ZUR SIMULATION VON FILMRAUSCHEN

TECHNIQUE FOR SIMULER LE GRAIN PRECIS EN BITS

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IT LI LU MC NL PL PT RO SE SI SK TR

(30) Priority: **14.10.2003 US 511026 P**

(43) Date of publication of application:
28.06.2006 Bulletin 2006/26

(73) Proprietor: **InterDigital VC Holdings, Inc.**
Wilmington, DE 19809 (US)

(72) Inventors:
- **BOYCE, Jill, Mac Donald**
  Manalapan, NJ 07726 (US)
- **GOMILA, Cristina**
  Princeton, NJ 08540 (US)
- **LLACH, Joan**
  Princeton, NJ 08540 (US)
- **TOURAPIS, Alexandros**
  Burbank, CA 91505 (US)
- **COOPER, Jeffrey, Allen**
  Rock Hill, NJ 08540 (US)
- **YIN, Peng**
  West Windsor, NJ 08540 (US)

(74) Representative: **Rolland, Sophie et al**
InterDigital CE Patent Holdings
20, rue Rouget de Lisle
92130 Issy-les-Moulineaux (FR)

(56) References cited:
WO-A-97/22204 **US-A- 5 641 596**
US-A1- 2003 206 662

- **CHRISTINA GOMILA: "SEI message for film grain encoding: syntax and results" JVT OF ISO IEC MPEG AND ITU-T VCEG JVT-I013 REVISION 2, 2 September 2003 (2003-09-02), pages 1-11, XP002308743 SAN DIEGO, CA, USA**
- **SCHLOCKERMANN M ET AL: "Film grain coding in H.264/AVC" JOINT VIDEO TEAM (JVT) OF ISO/IEC MPEG & ITU-T VCEG (ISO/IEC JTC1/SC29/WG11 AND ITU-T SG16 Q6), 2 September 2003 (2003-09-02), pages 1-8, XP002311238 SAN DIEGO, CA, USA**
- **CHRISTINA GOMILA, ALEXANDER KOBILANSKY: "SEI message for film grain encoding" JVT OF ISO IEC MPEG AND ITU-T VCEG JVT-H022, 23 May 2003 (2003-05-23), pages 1-14, XP002308742 GENEVA, SWITZERLAND**

EP 1 673 944 B1

Description

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority under 35 U.S.C. 119(e) to U.S. Provisional Patent Application Serial No. 60/511,026, filed on October 14, 2003.

TECHNICAL FIELD

[0002] This invention relates to a technique for simulating film grain in an image.

BACKGROUND ART

[0003] Motion picture films comprise silver-halide crystals dispersed in an emulsion, which is coated in thin layers on a film base. The exposure and development of these crystals form the photographic image consisting of discrete tiny particles of silver. In color negatives, tiny blobs of dye occur on the sites where the silver crystals form following chemical removal of the silver during development of the film stock. These small specks of dye commonly bear the label 'grain' in color film. Grain appears randomly distributed on the resulting image because of the random formation of silver crystals on the original emulsion. Within a uniformly exposed area, some crystals develop after exposure while others do not.

[0004] Grain varies in size and shape. The faster the film, the larger the clumps of silver formed and blobs of dye generated, and the more they tend to group together in random patterns. The term "granularity" typically refers to the grain pattern. The naked eye cannot distinguish individual grains, which vary from 0.0002 mm to about 0.002 mm. Instead, the eye resolves groups of grains, referred to as blobs. A viewer identifies these groups of blobs as film grain. As the image resolution becomes larger, the perception of the film grain becomes higher. Film grain becomes clearly noticeable on cinema and High Definition (HD) images, whereas film grain progressively loses importance in Standard Definition (SD) and becomes imperceptible in smaller formats.

[0005] Motion picture film typically contains image-dependent noise resulting either from the physical process of exposure and development of the photographic film or from the subsequent editing of the images. Photographic film possesses a characteristic quasi-random pattern, or texture, resulting from physical granularity of the photographic emulsion. Alternatively, simulation of similar pattern can occur in computed-generated images in order to blend them with photographic film. In both cases, this image-dependent noise bears the designation of "film grain." Quite often, moderate grain texture presents a desirable feature in motion pictures. In some instances, the film grain provides visual cues that facilitate the correct perception of two-dimensional pictures. Film grade often varies within a single film to provide various clues as to time reference, point of view, etc. Many other technical and artistic demands exist for controlling grain texture in the motion picture industry. Therefore, preserving the grainy appearance of images throughout image processing and delivery chain has become a requirement in the motion picture industry.

[0006] Several commercially available products have the capability of simulating film grain, often for blending a computer-generated object into natural scene. Cineon® from Eastman Kodak Co, Rochester New York, one of the first digital film applications to implement grain simulation, produces very realistic results for many grain types. However; the Cineon® application does not yield good performance for many high speed films because of the noticeable diagonal stripes the application produces for high grain size settings. Further, the Cineon® application fails to simulate grain with adequate fidelity when images become subject to prior processing, for example, such as when the images are copied or digitally processed.

[0007] Another commercial product that simulates film grain is *Grain Surgery*™ from Visual Infinity Inc., which is used as a plug-in of Adobe ® After Effects ®. The *Grain Surgery*™ product appears to generate synthetic grain by filtering a set of random numbers. This approach suffers from disadvantage of a high computational complexity. WO 97/22204 A (PRZYBORSKI, GLENN, B; GIBSON, ROBERT, F; HARN, JOHN, H; HUCKE, LLOYD,) 19 June 1997 (1997-06-19) discloses to perform film grain simulation by selecting pre-generated noise patterns by using a random number pointing to a memory address of the noise patterns. The selected noise patterns can be scaled based on user preferences before blending with a target image. US 2003/206662 A1 (AVINASH GOPAL B [US] ET AL) 6 November 2003 (2003-11-06) discloses to blend pre-generated film grain, which is adapted to the image pixel intensities on the fly, onto the input image. Thus, a need exists for an efficient film grain simulation technique, which reduces the need for memory bandwidth, and computational effort, thus permitting film grain simulation in cost-sensitive high volume devices, such as set top boxes.

BRIEF SUMMARY OF THE INVENTION

[0008] Briefly, in accordance with a preferred embodiment of the present principles, there is provided a method for simulating film grain in an image block of M x N pixels, where N and M are integers greater than zero. The method

commences by first computing the average of the pixel values within the block of M x N pixels. A film grain block of M x N pixels is selected from among a pool of previously established blocks containing film grain as a function of the average value of the image block and a random number. Each pixel in the selected film grain block is blended with a corresponding pixel in the image block.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009]

FIGURE 1 depicts a block schematic drawing of an apparatus for generating preestablished film grain blocks for use in subsequent film grain simulation; and
FIGURE 2 depicts a block schematic drawing of an apparatus in accordance with the present principles for simulating film grain on a pixel-by-pixel basis using the preestablished film grain blocks generated by the apparatus of FIG. 1.

DETAILED DESCRIPTION

Introduction

[0010] The method of the present principles simulates film grain in accordance with film grain information transmitted with an image to which simulated grain is blended. In practice, the transmitted image typically undergoes compression (encoding) prior to transmission via one of a variety of well-known compression schemes, such as the H.264 compression scheme. With the transmitted image compressed using the H.264 compression scheme, transmission of the film grain information typically occurs via a Supplemental Enhancement Information (SEI) message. Pursuant to contributions recently adopted by the standards body responsible for promulgating the H.264 standard, such as, CHRISTINA GOMILA, "SEI message for film grain encoding: syntax and results", JVT OF ISO IEC MPEG AND ITU-T VCEG JVT-I013 REVISION 2, 02-09-2003,SAN DIEGO, CA, USA, the SEI message can now include various parameters that specify different film grain attributes.

Constraints on the film grain SEI message parameters

[0011] The method of the present principles imposes some constraints with regard to the number of parameters and their range of possible values allowed by the H.264 recommendation. TABLE 1 provides a list of such parameters, including a description of their semantics and the constraints imposed by the present principles.

TABLE I

FILM GRAIN PARAMETER	DESCRIPTION & CONSTRAINTS
model_id	This parameter specifies the simulation model. It shall be 0, which identifies the film grain simulation model as frequency filtering.
separate_colour_ description_present_flag	This parameter specifies if the color space in which the parameters are estimated is different from the color space in which the video sequence (where the film grain SEI message has been embedded) has been encoded. It shall be 0, which identifies the color space for film grain the same than the encoded sequence.
blending_mode_id	This parameter identifies the blending mode used to blend the simulated film grain with the decoded images. It shall be 0, which correspond to an additive blending mode.
log2_scale_factor	This parameter identifies the logarithmic scale factor used to represent the film grain parameters in the SEI message. It shall be in the range [0, 4] to ensure film grain simulation can be performed using 16-bit arithmetic.
comp_model_present_flag [1]	This parameter enables the transmission of film grain parameters for the Cb color component in the YCbCr color space. It shall be 0, since film grain simulation in chroma is not supported.
comp_model_present_flag [2]	This parameter enables the transmission of film grain parameters for the Cr color component in the YCbCr color space. It shall be 0, since film grain simulation in chroma is not supported.

(continued)

FILM GRAIN PARAMETER	DESCRIPTION & CONSTRAINTS
no_intensity_intervals_ minus1[0]	This parameter defines the number of intensity intervals for which a specific set of parameters has been estimated. It shall be in the range [0, 7].
intensity_interval_lower_ bound[0][i+1], intensity_ interval_upper_bound[0][i]	These parameters define the boundaries of the luma intensity intervals for which different film grain parameters are defined. The lower bound of interval i+1 must be greater than the upper bound of interval i because multigenerational film grain is not allowed.
num_model_values_minus1 [0]	This parameter specifies the number of model values present for each intensity interval in which the film grain has been modeled. It shall be in the range [0,4] because color correlation is not allowed.
comp_model_value[0][i][0]	This parameter represents the film grain intensity for each luminance intensity interval in which film grain has been modeled. It shall be in the range [0,255] to ensure film grain simulation can be performed using 16-bit arithmetic.

[0012] In addition to the previous constraints, the present principles imposes that film grain SEI messages precede I pictures, and only one film grain SEI message can precede a particular I picture. (The presence in the bit stream of **slice_type** equal to 7 or **nal_ref_idc** equal to 5, indicates an I picture.)

[0013] All the other parameters of the film grain SEI message have no constraint with respect to the standard specification.

Bit-accurate implementation of film grain simulation

[0014] Film grain simulation in accordance with the present principles occurs in a two-step process. First, generation of a pool of film grain blocks occurs during initialization, as described in greater detail with respect to FIG. 1. Thereafter, selected film grain portions are added to each luminance pixel of each decoded picture as described with respect to FIG. 2.

[0015] FIGURE 1 depicts an apparatus 10 in accordance with an illustrated embodiment of the present principles for generating a pool of film grain blocks for use in film grain simulation. The apparatus 10 typically generates a pool of 128 film grain blocks for each of as many as 8 different luminance intensity intervals. The SEI message field **num_intensity_intervals_minus1[0]** indicates one less than the number of the luminance intensity intervals.

[0016] The apparatus 10 accomplishes film grain noise initialization using a specified uniform pseudo-random number polynomial generator 12 and using a specified list of 2048 8-bit Gaussian distributed random numbers stored in a look-up table 14 The look-up table 14 stores random numbers in 2's complement form in the range [-63, 63]. The list of Gaussian random numbers appears in the Appendix.

[0017] According to the bit-accurate specification of the present principles, generation of the film grain blocks begins with the lowest luminance intensity interval. The uniform random number generator 12 generates an index for the Gaussian random number list stored in the look-up table 14 using a primitive polynomial modulo 2 operator, $x^{18} + x^5 + x^2 + x^1 + 1$. For ease of understanding, the term x(i, s) will indicate the i^{th} symbol of the sequence x, beginning with an initial seed s. The random number seed becomes reset to 1 upon the receipt of each film grain SEI message.

[0018] To form an individual 8x8 film grain block, a random block generator 16 reads 8 lines worth of 8 random numbers from the Gaussian random number look-up table 14. A random offset, from the random number generator 12, serves to access each line of 8 random numbers. Each line of the block produced by the block generator 16 is generated as following:

index = x(i, 1)
for n=0...7, B[i%8][n] = Gaussian_list[(index + n)%2048]
where i increments for each 8x1 block line.

[0019] The 8 x 8 block of random values read by the generator 16 undergoes a transform, typically an integer Discrete Cosine Transform (DCT), performed by an Integer DCT transform block 18. After the DCT transform, the 8 x 8 random values undergo frequency filtering at a frequency filter 20 in accordance with the cut frequencies specified in the SEI message. Following frequency filtering, the 8 x 8 random values undergo an inverse DCT transform by an inverse integer DCT block 22. A first scaling block 24 scales the pixels on the top and bottom block lines as follows:

for n=0..7, B'[0][n] = (B[0] [n] + 1) >> 1

for n=0..7, B'[7][n] = (B[7] [n] + 1) >> 1

[0020] This process continues until generation of a set of 128 film grain blocks for each luminance intensity interval. Following subsequent scaling by the second scaling block 26, the film grain blocks undergo storage in the film grain pool 28.

Block and Pixel Operations to Simulate Film Grain

[0021] FIGURE 2 illustrates an apparatus 200 in accordance with an illustrative embodiment of the present principles for simulating film grain on a pixel-by-pixel basis using the stored values in the film grain pool 28. The apparatus 200 includes a processing block 202 for creating an average of each 8 x 8 block of luma pixel values for comparison to the parameters **intensity_interval_lower_bound[0][i]** and **intensity_interval_upper_bound[0][i]** in the film grain SEI message to determine the correct luminance intensity interval for the current block.

[0022] A selector block 204 selects a k^{th} film grain block from the pool 28, using the random number generated by the uniform random number generator 16 from the polynomial modulo 128 as the block index. Thus, the noise generator 16, which generates uniformly distributed random numbers using a polynomial for the initialization process described with respect to FIG. 1, finds application in the apparatus 200 of FIG. 2 to select film grain blocks, with the random number seed reset to 1 after the pool creation process. If the resulting block index is identical to the previous one, the last bit of the index undergoes toggling. Such operation can occur using a bit-wise comparison and an XOR operator (^) as follows:

```
previous_index = index
index = x(k, 1) % 128
index ^= (index == previous_index)
```

[0023] Following block selection, a deblocking filter 206 deblocks the pixels on the right most column of the previously selected block and on the left most column of the current block. An adder 208 adds the deblocked film grain block to decoded luma pixels. (Since two horizontally adjacent blocks are required to perform deblocking, there is a 1-block delay between the block selected in 204 and the block added in 208.) A clipper 210 clips the result within the range [0, 255] for display. Note that film grain noise addition only occurs to luma pixels.

Scaling of Cut Frequencies

[0024] The parameters in the film grain SEI message of TABLE 1 assume the use of a 16 x 16 DCT in the simulation process. In particular, horizontal and vertical high cut frequencies, provided by **comp_model_value[0][i][1]** and **comp_model_value[0][i][2],** and horizontal and vertical low cut frequencies, provided by **comp_model_value[0][i][3]** and **comp_model_value[0][i][4],** serve to filter the transform coefficients of a block of 16x16 values.

[0025] In the illustrated embodiment, the use of 8 x 8 blocks will reduce complexity. Employing an 8 x 8 block transform using cut frequency parameters based on a 16 x 16 transform implies that all the cut frequencies require scaling before the grain generation.

[0026] The scaling of the cut frequencies occurs as follows:

$$comp\_model\_value'[0][i][j] = (comp\_model\_value\ [0][i][j] + 1) >> 1$$

where j is in the range [1,4]. Note that the scaling constitutes the equivalent of the integer division, rounded up to the nearest integer.

Integer Transform and Variance Scaling

[0027] The transform used for the frequency filtering corresponds to an 8 x 8 integer approximation to the DCT, using the following transformation matrix:

$$\mathbf{T}_8 = \begin{pmatrix} 6 & 6 & 6 & 6 & 6 & 6 & 6 & 6 \\ 8 & 7 & 4 & 2 & -2 & -4 & -7 & -8 \\ 7 & 3 & -3 & -7 & -7 & -3 & 3 & 7 \\ 7 & -2 & -8 & -4 & 4 & 8 & 2 & -7 \\ 6 & -6 & -6 & 6 & 6 & -6 & -6 & 6 \\ 4 & -8 & 2 & 7 & -7 & -2 & 8 & -4 \\ 3 & -7 & 7 & -3 & -3 & 7 & -7 & 3 \\ 2 & -4 & 7 & -8 & 8 & -7 & 4 & -2 \end{pmatrix}$$

[0028] 16-bit arithmetic can be used. The forward integer transformation of a given block of random noise is defined as:

$$\tilde{\mathbf{B}} = (((\mathbf{T}_8 \times \mathbf{B} + 8) >> 4) \times \mathbf{T}_8^{\,T} + 8) >> 4$$

with 11 bits used for $\tilde{\mathbf{B}}$.

[0029] The inverse integer transform is defined as:

$$\mathbf{B} = (\mathbf{T}_8^{\,T} \times \tilde{\mathbf{B}} \times \mathbf{T}_8 + 128) >> 8$$

with 8 bits used for B.

[0030] Following the inverse transform, the block B undergoes scaling as follows, assuming it is in the k^{th} luminance intensity interval,

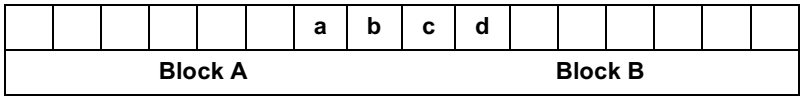
$$val = B(i, j) * comp\_model\_value[0][k][0]$$

$$B'(i, j) = (((val - (val >>4) + 2^{log2\_scale\_factor - 1}) >> log2\_scale\_factor) + 16) >> 5$$

where the operation (val - (val>>4)) compensates the scaling of the integer transform; log2_scale_factor, transmitted in the SEI message, scales comp_model_value[0][k][0]; and 5 scales the Gaussian numbers provided in the Appendix.

Deblocking filter 206

[0031] As indicated, the film grain simulation apparatus of FIG. 2 includes a deblocking filter 206 for smoothing blocking artifacts resulting from the small size of the transform. In the illustrated embodiment, the deblocking filter 206 takes the form of a 3-tap filter applied to all pixels bordering the 8x8 block left and right edges. Given a row of pixels belonging to two adjacent 8x8 blocks, the transition between blocks being located between pixels b and c,



application of the deblocking occurs as follows:

$$b' = (a + (b << 1) + c) >> 2$$

$$c' = (b + (c << 1) + d) >> 2$$

where b' and c' replace the value of the original pixels b and c, respectively. Deblocking of the left and right block edges occurs for every film grain block before addition to the decoded image.

[0032] The foregoing describes a technique for simulating film grain in an image.

Appendix

[0033] The list of the 2048 Gaussian distributed random numbers are:

char Gaussian[2048] = { 0xFB, 0x05, 0x33, 0xFB, 0x14, 0xEF, 0x06, 0x1D, 0x26, 0x30, 0xD5, 0x01, 0x20, 0xD9, 0x16, 0x1B, 0xE7, 0x0A, 0x06, 0xFB, 0xF6, 0xF7, 0x10, 0xC1, 0x08, 0xFE, 0xCC, 0x09, 0x09, 0x23, 0x17, 0xFB, 0xED, 0x15, 0xFF, 0x25, 0xDF, 0x1A, 0xD3, 0x10, 0xE9, 0x0A, 0xFF, 0xE5, 0x18, 0x00, 0xE4, 0xEC, 0x00, 0x3C, 0xC1, 0xCB, 0xE8, 0x04, 0x07, 0x3F, 0x3D, 0x36, 0x19, 0x3F, 0x00, 0x03, 0x38, 0x09, 0x0E, 0x06, 0x26, 0x38, 0x28, 0xE2, 0xC1, 0x37, 0xE7, 0xF2, 0x01, 0xE8, 0xF5, 0x1D, 0xF2, 0xDC, 0x05, 0x38, 0x21, 0x27, 0xFF, 0xC7, 0xD5, 0xFE, 0xFE, 0x14, 0x1D, 0xD8, 0x18, 0xF3, 0xF1, 0xEF, 0xCC, 0x19, 0x08, 0xF4, 0xEF, 0xFA, OxF9, 0xC1, 0xE5, 0xF5, 0xE5, 0xC1, 0xC8, 0x02, 0xF4, 0xDC, 0x3F, 0x3F, 0xFF, 0x14, 0x2B, 0xE0, 0xF9, 0x1B, 0x09, 0x2D, 0xD8, 0xE0, 0xE0, 0x11, 0xFD, 0xE5, 0x31, 0xFD, 0x2C, 0x3E, 0xF3, 0x2D, 0x00, 0x1F, 0x1D, 0xF9, 0xF5, 0x38, 0xF0, 0x3A, 0x06, 0x0C, 0x19, 0xF8, 0x35, 0xFD, 0x1A, 0x13, 0xEF, 0x08, 0xFD, 0x02, 0xD3, 0x03, 0x1F, 0x1F, 0xF9, 0x13, 0xEE, 0x09, 0x1B, 0x08, 0xE7, 0x13, 0x10, 0xEE, 0x3E, 0xED, 0xC5, 0x08, 0xF1, 0x00, 0x09, 0x31, 0x1E, 0x32, 0xFA, 0xDC, 0xF8, 0xE7, 0x31, 0x01, 0x01, 0x1D, 0x10, 0xFF, 0xFF, 0x04, 0xEC, 0xCC, 0xEE, 0x06, 0x3F, 0x07, 0xC1, 0xF1, 0xD5, 0xED, 0xE5, 0x16, 0xEC, 0x25, 0x0B, 0xF7, 0xF5, 0xDD, 0x25, 0xE6, 0x00, 0x10, 0xEA, 0x08, OxD2, 0x1D, 0xE0, 0xDF, 0x1B, 0xCE, 0xF2, 0xD5, 0xEF, 0xD2, 0x21, 0x02, 0xDC, 0xE2, 0x2E, 0xEB, 0x06, 0xF4, 0xEE, 0xC1, 0xF8, 0x07, 0xC1, 0x1F, 0x11, 0x0F, 0x2E, 0x08, 0xE7, OxE3, 0x23, 0x26, 0x28, 0x3F, 0x3F, 0x1E, 0x10, 0xCC, 0xD2, 0x00, 0x00, 0x25, 0xDE, 0x23, 0x3F, 0xF7, 0xC9, 0x0E, 0x0B, 0x07, 0x01, 0x13, 0x2D, 0x02, 0x14, 0x00, 0xFE, 0x13, 0x07, 0x38, 0xF2, 0xEE, 0x19, 0x15, 0x35, 0x0D, 0x3B, 0x03, 0xD9, 0x0C, 0xDE, 0xF6, 0x2E, 0xFB, 0x00, 0x09, 0x14, 0xE7, 0x27, 0xC1, 0xEB, 0x3F, 0x08, 0x05, 0xF6, 0x0F, 0xE7, 0x0D, 0xD4, 0xD3, 0xED, 0xF7, 0xFC, 0x0C, 0xC6, 0x23, 0xF4, 0xEB, 0x00, 0x05, 0x2A, 0xCB, 0x13, 0xF0, 0xC1, 0x17, 0x19, 0xF4, 0xF6, 0x16, 0x00, 0x07, 0xEF, 0xDE, 0x00, 0xDC, 0x0C, 0xFD, 0x00, 0x0E, 0xFF, 0x16, 0x10, 0xF0, 0x3A, 0xEA, 0x27, 0xF5, 0xF8, 0xCA, 0xFB, 0xDD, 0x2C, 0xE9, 0x0B, 0xD3, 0x3B, 0xEE, 0x18, 0xC1, 0x1D, 0x10, 0xD8, 0xFB, 0xF8, 0xFD, 0x16, 0xC1, 0xF9, 0x2C, 0x3F, 0x08, 0x31, 0xED, 0xF0, 0x12, 0x15, 0xED, 0xF1, 0xF6, 0x34, 0xF7, 0x09, 0x09, 0xE3, 0xFC, 0x0F, 0x00, 0xC1, 0x10, 0x3F, 0xD6, 0x25, 0x0B, 0xEC, 0xE8, 0xC1, 0xCB, 0xF9, 0x16, 0xDB, 0x00, 0x0E, 0xF7, 0x14, 0xDE, 0xED, 0x06, 0x3F, 0xFF, 0x02, 0x0A, 0xDC, 0xE3, 0xC1, 0xFF, 0xFF, 0xE6, 0xFE, 0xC5, 0x2E, 0x3B, 0xD8, 0xE8, 0x00, 0x09, 0xEA, 0x21, 0x26, 0xFA, 0xF6, 0xC1, 0x11, 0xEC, 0x1B, 0x3B, 0xFE, 0xC7, 0xF5, 0x22, 0xF9, 0xD3, 0x0C, 0xD7, 0xEB, 0xC1, 0x35, 0xF4, 0xEE, 0x13, 0xFD, 0xFD, 0xD7, 0x02, 0xD5, 0x15, 0xEF, 0x04, 0xC1, 0x13, 0x22, 0x18, 0xE1, 0x24, 0xE8, 0x36, 0xF3, 0xD4, 0xE9, 0xED, 0x16, 0x18, 0xFF, 0x1D, 0xEC, 0x28, 0x04, 0xC1, 0xFC, 0xE4, 0xE8, 0x3E, 0xE0, 0x17, 0x11, 0x3A, 0x07, 0xFB, 0xD0, 0x36, 0x2F, 0xF8, 0xE5, 0x22, 0x03, 0xFA, 0xFE, 0x18, 0x12, 0xEA, 0x3C, 0xF1, 0xDA, 0x14, 0xEA, 0x02, 0x01, 0x22, 0x08, 0xD9, 0x00, 0xD9, 0x02, 0x3F, 0x15, 0x0D, 0x3F, 0xC1, 0x0D, 0xE5, 0xF3, 0x1B, 0x37, 0x17, 0x35, 0x00, 0xDA, 0x00, 0x1A, 0xFC, 0xF5, 0xEB, 0x3D, 0x36, 0x3F, 0x32, 0x21, 0x17, 0x02, 0x00, 0x3D, 0xFA, 0xE5, 0xF0, 0xE8, 0x2C, 0x20, 0xCC, 0xFE, 0x2F, 0xE6, 0x1F, 0x16, 0x0E, 0x17, 0x09, 0xEF, 0x07, 0x14, 0x17, 0xD0, 0xF4, 0x2F, 0xDB, 0x3F, 0xC7, 0x3F, 0xDF, 0x00, 0xF8, 0x19, 0xD1, 0x17, 0x05, 0x11, 0xEA, 0xDB, 0x2C, 0xCB, 0xFC, 0xE4, 0xF2, 0xCA, 0xF4, 0x3F, 0xE2, 0xFA, 0x26, 0xEA, 0x08, 0x09, 0x29, 0xF5, 0x04, 0x3F, 0xDF, 0x1A, 0x01, 0x0C, 0x06, 0x37, 0x15, 0xC8, 0xF5, 0x05, 0xF4, 0x29, 0x21, 0xFA, 0x25, 0xC3, 0x1D, 0x3F, 0xFB, 0x31, 0xF7, 0x1F, 0xED, 0x1A, 0x04, 0x03, 0x1E, 0xE5, 0x01, 0xE4, 0x38, 0xCC, 0xE3, 0x01, 0xFC, 0xE9, 0x24, Ox2A, 0xE5, 0xEF, 0x06, 0x3B, 0x0D, 0x2E, 0xDD, 0x06, 0xCF, 0xDD, 0xF6, 0x0E, 0x23, 0xD1, 0x09, 0xE6, 0x20, 0xFA, 0xE1, 0xF4, 0x20, 0x24, 0xFC, 0x3F, 0x00, 0xC1, 0x33, 0xF6, 0xDC, 0xC9, 0xCD, 0xFD, 0x0E, 0xEC, 0xF6, 0xE3, 0xF2, 0xF4, 0x09, 0xFE, 0xE7, 0x2F, 0xE3, 0xD1, 0xEE, 0x11, 0x09, 0xDE, 0x3F, 0xF7, 0xC1, 0xF5, 0xC5, 0xE6, 0x12, 0x25, 0xC1, 0x00, 0xFB, 0xC5, 0xE6, 0xF3, 0x13, 0x22, 0x08, 0x08, 0xC7, 0x2C, 0x1F, 0x0C, 0x12, 0xF5, 0x18, 0xCE, 0xF1, 0xFC, 0xD1, 0xE6, 0x02, 0x2E, 0xF5, 0xE8, 0xFC, 0x19, 0x01, 0xDB, 0xD4, 0xFB, 0xED, 0x3F, 0xD5, 0xF5, 0x09, 0x0A, 0x38, 0x25, 0x19, 0xF1, 0x2E, 0xE1, 0x03, 0xFB, 0x17, 0x12, 0x32, 0xEB, 0xF8, 0xE6, 0xFD, 0xEE, 0xDA, 0xF1, 0xF6, 0x1F, 0x0F, 0x1F, 0x0A, 0xC1, 0x0F, 0x1F, 0x12, 0x33, 0xD6, 0xFC, 0x26, 0x27, 0x1D, 0xD9, 0xFD, 0x11, 0x04, 0x28, 0xF4, 0xFC, 0x01, 0xF8, 0x23, 0x3F, 0x29, 0xD5, 0x1B, 0x09, 0xC5, 0xC3, 0x12, 0x05, 0x3F, 0x1C, 0xE5, 0x38, 0x06, 0x0C, 0x10, 0xFA, 0xE9, 0x0A, 0xFA, 0x02, 0x1C, 0x0D, 0x0C, 0x0C, 0xFB, 0xEE, 0x12, 0xD2, 0x26, 0x28, 0x04, 0x19, 0x06, 0x21, 0xFA, 0x00, 0x10, 0x16, 0xDB, 0x10, 0xED, 0xF5, 0xE8, 0xC1, 0xF3, 0x0F, 0xFC, 0x11, 0x06, 0x23, 0x06, 0x1C, 0x05, 0xE6, 0xD6, 0x1A, 0xEA, 0xEF, 0x00, 0x3F, 0x05, 0xDF, 0xEA, 0x17, 0xC7, 0x01, 0x05, 0x1C, 0xEF, 0x3B, 0xF7, 0xE2, 0x1A, 0xE3, 0xC1, 0xE8, 0xF5, 0x01, 0xFE, 0x08, 0xD8, 0xFE, 0x3F, 0x0C, 0x27, 0x21, 0x1F, 0xF4, 0x06, 0xE0, 0xEE, 0xC1, 0xF2, 0x0A, 0xE1, 0x20, 0xE6, 0xEC, 0x36, 0xE1, 0x07, 0xF6, 0x06, 0x0E, 0xE1, 0x0A, 0x0D, 0x2F, 0xEA, 0xE3, 0xC6, 0xFC, 0x27, 0xE8, 0x0B, 0xEB, 0xF8, 0x17, 0xE9, 0xC4, 0xEF, 0xF2, 0xE6,

0xEA, 0x0E, 0x3F, 0xFA, 0x18, 0xFC, 0xC1, 0x25, 0xF3, 0xF5, 0x2C, 0x1D, 0x05, 0xD1, 0x28, 0xE3, 0x1D, 0x1E, 0xF4, 0x14, 0xD3, 0xFF, 0xF6, 0xE3, 0xEA, 0xE3, 0xF5, 0xE6, 0x23, 0xF2, 0x21, 0xF1, 0xF5, 0x07, 0xF8, 0xDF, 0xF4, 0xF2, 0xE2, 0x17, 0x12, 0x08, 0x07, 0xEE, 0xF5, 0xFB, 0x04, 0xF3, 0xF7, 0x1D, 0x16, 0xE8, 0xE9, 0xFF, 0xF6, 0xD8, 0x0E, 0xDF, 0xC1, 0x25, 0x32, 0x02, 0xF8, 0x30, 0x11, 0xE0, 0x14, 0xE7, 0x03, 0xE3, 0x0B, 0xE4, 0xF7, 0xF4, 0xC5, 0xDC, 0x2D, 0x07, 0xF9, 0x27, 0xF0, 0xD9, 0xC1, 0xEF, 0x14, 0x26, 0xD7, 0x00, 0x1B, 0x0B, 0xDB, 0x3F, 0xF8, 0xF6, 0x06, 0x0F, 0x1B, 0xC8, 0xC1, 0x2C, 0x1B, 0x1E, 0x06, 0x1B, 0xFA, 0xC8, 0xF9, 0x0F, 0x18, 0xDF, 0xF8, 0x2D, 0xFC, 0x00, 0x0A, 0x22, 0xDD, 0x31, 0xF7, 0xC8, 0x20, 0xD3, 0xFC, 0xFC, 0xDD, 0x3F, 0x19, 0xD8, 0xE8, 0x0C, 0x1E, 0xE2, 0xC9, 0x03, 0xEC, 0x3F, 0x2B, 0xE0, 0x35, 0xC1, 0xFE, 0x11, 0xF9, 0x14, 0xE8, 0x06, 0x06, 0x24, 0xCE, 0xF3, 0x26, 0x3F, 0xFD, 0xCE, 0x2C, 0x12, 0x3C, 0x2C, 0xC2, 0xE3, 0x06, 0xD2, 0xC7, 0x0A, 0xDF, 0xD5, 0xD1, 0xC5, 0x15, 0xF2, 0xF1, 0x08, 0x02, 0xE6, 0xE2, 0x0A, 0xEB, 0x05, 0xDA, 0xE3, 0x06, 0x0E, 0x01, 0x03, 0xDC, 0x13, 0xE3, 0xFB, 0x36, 0xE6, 0x14, 0x21, 0xFA, 0xC1, 0xC1, 0xE8, 0x0B, 0x0E, 0x17, 0x11, 0x2D, 0x11, 0xF0, 0x39, 0xE7, 0xF0, 0xE7, 0x2D, 0x03, 0xD7, 0x24, 0xF4, 0xCD, 0x0C, 0xFB, 0x26, 0x2A, 0x02, 0x21, 0xD8, 0xFA, 0xF8, 0xF0, 0xE8, 0x09, 0x19, 0x0C, 0x04, 0x1F, 0xCD, 0xFA, 0x12, 0x3F, 0x38, 0x30, 0x11, 0x00, 0xF0, 0xE5, 0x3F, 0xC3, 0xF0, 0x1E, 0xFD, 0x3B, 0xF0, 0xC1, 0xE6, 0xEB, 0x1F, 0x01, 0xFE, 0xF4, 0x23, 0xE4, 0xF0, 0xEB, 0xEB, 0x10, 0xE4, 0xC1, 0x3F, 0x0C, 0xEF, 0xFB, 0x08, 0xD8, 0x0E, 0xE4, 0x14, 0xC1, 0xC1, 0x0A, 0xE9, 0xFB, 0xEF, 0xE1, 0xE7, 0xF0, 0xD8, 0x27, 0xDA, 0xDC, 0x04, 0x0D, 0xDC, 0xFC, 0xDB, 0xD6, 0xD6, 0xE4, 0x0C, 0x27, 0xFC, 0xD0, 0x11, 0xE0, 0x04, 0xE3, 0x07, 0x00, 0xEC, 0x10, 0xD5, 0xEA, 0x08, 0xFF, 0xFC, 0x1D, 0x13, 0x05, 0xCA, 0xED, 0x0B, 0x10, 0x08, 0xF2, 0x01, 0x19, 0xCA, 0xFE, 0x32, 0x00, 0x20, 0x0B, 0x00, 0x3F, 0x1E, 0x16, 0x0C, 0xF1, 0x03, 0x04, 0xFD, 0xE8, 0x31, 0x08, 0x15, 0x00, 0xEC, 0x10, 0xED, 0xE6, 0x05, 0xCA, 0xF7, 0x1C, 0xC1, 0x22, 0x0D, 0x19, 0x2E, 0x13, 0x1E, 0xE7, 0x16, 0xED, 0x06, 0x2A, 0x3C, 0x0D, 0x21, 0x16, 0xC9, 0xD7, 0xFF, 0x0F, 0x12, 0x09, 0xEE, 0x1D, 0x23, 0x13, 0xDA, 0xE9, 0x1D, 0xD9, 0x03, 0xE1, 0xEF, 0xFA, 0x1E, 0x14, 0xC1, 0x23, 0xFE, 0x0B, 0xE5, 0x19, 0xC1, 0x21, 0xFE, 0xEC, 0x0E, 0xE1, 0x1D, 0xFF, 0x00, 0xF7, 0xEA, 0xD2, 0xD8, 0xD0, 0xF9, 0xE6, 0xFB, 0xFB, 0xDA, 0x06, 0x00, 0x03, 0xDF, 0xC1, 0x3F, 0xF3, 0x0D, 0xFA, 0x08, 0xFA, 0xF3, 0x00, 0x04, 0xE9, 0xF0, 0xF9, 0x0D, 0xF1, 0xE3, 0x1D, 0x26, 0xC4, 0x0D, 0x13, 0xE5, 0xE1, 0xF1, 0xF6, 0xEE, 0xF1, 0xFD, 0xC1, 0xF4, 0xE2, 0x23, 0xC1, 0x38, 0xC1, 0x3F, 0x2B, 0xFD, 0x39, 0x36, 0x1A, 0x2B, 0xC1, 0x01, 0x07, 0x0B, 0x25, 0xCC, 0xE7, 0x01, 0x24, 0xD8, 0xC9, 0xDB, 0x20, 0x28, 0x0C, 0x1A, 0x3F, 0xEA, 0xE7, 0xCD, 0xEC, 0xE0, 0xF2, 0x27, 0xDF, 0x20, 0xF0, 0xF1, 0xFD, 0x3F, 0x00, 0xFA, 0xE7, 0x21, 0xF9, 0x02, 0xD2, 0x0E, 0xEF, 0xFD, 0xD3, 0xE4, 0xFF, 0x12, 0x15, 0x16, 0xF1, 0xDE, 0xFD, 0x12, 0x13, 0xE7, 0x15, 0xD8, 0x1D, 0x02, 0x3F, 0x06, 0x1C, 0x21, 0x16, 0x1D, 0xEB, 0xEB, 0x14, 0xF9, 0xC5, 0x0C, 0x01, 0xFB, 0x09, 0xFA, 0x19, 0x0E, 0x01, 0x1B, 0xE8, 0xFB, 0x00, 0x01, 0x30, 0xF7, 0x0E, 0x14, 0x06, 0x15, 0x27, 0xEA, 0x1B, 0xCB, 0xEB, 0xF7, 0x3F, 0x07, 0xFB, 0xF7, 0xD8, 0x29, 0xEE, 0x26, 0xCA, 0x07, 0x20, 0xE8, 0x15, 0x05, 0x06, 0x0D, 0x0D, 0x1E, 0x1C, 0x0F, 0x0D, 0x35, 0xF7, 0x1B, 0x06, 0x30, 0x02, 0xFD, 0xE2, 0xCD, 0x2F, 0x35, 0xEB, 0x1A, 0x0D, 0xE9, 0xFC, 0x34, 0xE6, 0x17, 0x2C, 0x33, 0xF0, 0x13, 0xEF, 0x1B, 0x19, 0x23, 0xD1, 0xEF, 0xD5, 0xCB, 0xF7, 0xF1, 0x04, 0xF7, 0x27, 0xF9, 0x26, 0x02, 0XF7, 0xCB, 0x2A, 0x0A, 0xEA, 0xED, 0xEC, 0x04, 0xF2, 0x25, 0x17, 0xDB, 0x1E, 0xC1, 0x3C, 0xC9, 0xE4, 0xF1, 0x14, 0x03, 0x27, 0x25, 0x21, 0x1C, 0x14, 0xF4, 0x0F, 0x12, 0xE9, 0xEE, 0x15, 0xDC, 0xEE, 0x1F, 0x3F, 0xDE, 0xE7, 0x2C, 0xF0, 0xE2, 0x1D, 0xE5, 0x15, 0x07, 0x02, 0xDF, 0x06, 0xD3, 0x1F, 0x0E, 0xED, 0xFF, 0x29, 0xFF, 0xED, 0xD6, 0xD6, 0x1C, 0x11, 0xDE, 0xE2, 0x0E, 0xEE, 0xD1, 0xD9, 0x02, 0x0F, 0xFE, 0xF0, 0xD9, 0xF6, 0xFC, 0xDA, 0x16, 0x03, 0xD2, 0xDD, 0x20, 0x04, 0xE8, 0x3F, OxDE, 0x0C, 0xFB, 0xED, 0xC7, 0x1F, 0xC1, 0xCE, 0x02, 0xF1, 0x37, 0x0B, 0xE3, 0x20, 0xCE, 0x0D, 0xEB, 0x0A, 0xE3, 0xF3, 0xDC, 0x01, 0xD2, 0x02, 0x3F, 0x02, 0x25, 0xD5, 0xFC, 0xEB, 0xCE, 0x3F, 0x00, 0x3E, 0x2D, 0xE1, 0x19, 0x1C, 0x01, 0x28, 0xC1, 0x3F, 0x27, 0x3F, 0xF2, 0x0E, 0x3A, 0xDB, 0xF8, 0xE4, 0x34, 0x18, 0x16, 0x0C, 0xDD, 0x18, 0xED, 0xCB, 0x0F, 0xF0, 0x01, 0xFB, 0x14, 0xC1, 0x19, 0xCC, 0xEB, 0xEE, 0x19, 0x00, 0x17, 0x2B, 0xFC, 0x26, 0x0D, 0xEC, 0xF4, 0x2D, 0x2B, 0xE5, 0x25, 0x05, 0x10, 0x26, 0x1D, 0x3F, 0x3F, 0xFD, 0xDC, 0x18, 0xF0, 0xCB, 0xEF, 0x12, 0x1C, 0x1A, 0xF8, 0xFE, 0x29, 0x1A, 0xCB, 0x1A, 0xC2, 0x0E, 0x0B, 0x1B, 0xEB, 0xD5, 0xF8, 0xFD, 0x17, 0x0B, 0xFC, 0x00, 0xFA, 0x37, 0x25, 0x0D, 0xE6, 0xEE, 0xF0, 0x13, 0x0F, 0x21, 0x13, 0x13, 0xE1, 0x12, 0x01, 0x0A, 0xF1, 0xE7, 0xF3, 0x1A, 0xED, 0xD5, 0x0A, 0x19, 0x39, 0x09, 0xD8, OxDE, 0x00, 0xF9, 0xE9, 0xEA, 0xFF, 0x3E, 0x08, 0xFA, 0x0B, 0xD7, 0xD7, 0xDE, 0xF7, 0xE0, 0xC1, 0x04, 0x28, 0xE8, 0x1E, 0x03, 0xEE, 0xEA, 0xEB, 0x1C, 0xF3, 0x17, 0x09, 0xD6, 0x17, 0xFA, 0x14, 0xEE, 0xDB, 0xE2, 0x2A, 0xD9, 0xC1, 0x05, 0x19, 0x00, 0xFF, 0x06, 0x17, 0x02, 0x09, 0xD9, 0xE5, 0xF3, 0x20, 0xDD, 0x05, 0xCB, 0x09, 0xF8, 0x05, 0xF1, 0x1F, 0xE5, 0x12, 0x25, 0xF8, 0x3F, 0xDC, 0xF0, 0xF2, 0xC5, 0x34, 0x21, 0x35, 0xCD, 0xCC, 0x23, 0x1E, 0x01, 0x0B, 0xFF, 0x10, 0xFE, 0xF9, 0xDF, 0xF9, 0xF5, 0xE5, 0x07, 0xE1, 0x25, 0x1C, 0xC9, 0x00, 0x29, 0xF3, 0x0A, 0x25, 0xED, 0xF8, 0xFB, 0x20, 0xF8, 0xC1, 0xE5, 0xE0, 0x0F, 0x2F, 0x3A, 0x01, 0xC8, 0xFD, 0xCA, 0xE1, 0x30, 0x04, 0x19, 0x03, 0x25, 0xF3, 0x24, 0x38, 0xEE, 0xC9, 0x2F, 0xE7, 0x0B, 0xFA, 0xF7, 0x1B, 0x0A, 0x0B, 0x2D, 0x2D, 0x0B, 0xE8, 0x08, 0xDB, 0x0B, 0x04, 0xE8, 0xD0, 0xEE, 0x18, 0xEF, 0x11, 0xC1, 0xD6, 0x15, 0x3F, 0xF5, 0xF4, 0x2A, 0x29, 0xEF, 0xF0, 0xFA, 0x36, 0x33, 0xED, 0x19, 0xDF, 0x11, 0x09, 0xF5, 0x18, 0xF1, 0x3F, 0x14, 0x0C, 0xD2, 0xFF, 0xFF, 0x34, 0x01, 0xE4, 0xF8, 0x03, 0x3F, 0xF8, 0x3E, 0x21, 0x22, 0xE2, 0x0F, 0xEF, 0x1A, 0xE4, 0xF5, 0x08, 0x15, 0xEF, 0xF3, 0xE4, 0xDF, 0xF6, 0xFC, 0xE8, 0x21, 0x06, 0x20, 0x02, 0x17, 0x1B, 0x3F, 0xDB, 0x16, 0x2C, 0xE0, 0xFA, 0xDA, 0xD8, 0xD3, 0x0B, 0x0E, 0x10, 0xED, 0xD5, 0xF0, 0x30, 0xD3, 0x13, 0x04, 0xE1, 0xFF, 0xFB, 0x3F, 0xE8, 0xEE, 0xE5, 0x0B, 0xEF, 0xEF, 0xE6, 0x2C, 0xD3, 0x00, 0x18, 0x26, 0xFE, 0xC1, 0x08, 0x16, 0xFE, 0xDC, 0x00, 0xE4, OxF7, 0xDC, 0x0E, 0x2E, 0x1D,

0x18, 0x0A, 0x08, 0x37, 0xC9, 0x10, 0xD7, 0x17, 0x17, 0xFB, 0x11, 0xD5, 0x15, 0x1C, 0xD0, 0x3F, 0xF8, 0x00, 0x00, 0xED, 0xC1, 0xFF, 0x00, 0x1F, 0x2E, 0x00, 0x12, 0xE0, 0xE2, 0xF7, 0x13, 0xC1, 0x1C, 0x18, 0xF8, 0x3F, 0x2C, 0xEB, 0xCA, 0xE7, 0xF8, 0x03, 0xEE, 0x22, 0x17, 0xF9, 0x35, 0x14, 0x1C, 0x03, 0x09, 0x03, 0x01, 0x2B, 0xD4, 0xD2, 0xF8, 0xF6, 0xF5, 0x06, 0x03, 0xFE, 0xDA, 0xD3, 0xFF, 0x03, 0xEF, 0xFE, 0x09, 0x01, 0xC9, 0x02, 0xDF, 0xD8, 0x3C, 0xF7, 0xF0, 0xEE, 0xD6, 0x3F, 0x21, 0x16, 0x08, 0x17 };

Claims

1. A method for simulating film grain in an image block comprising: computing the average of the pixel luminance values within the image block; selecting a film grain block from among a pool of previously established blocks containing film grain wherein selection is performed as a function of the average luminance value of the image block and a random number; and
blending each pixel in the selected film grain block with a corresponding pixel in the image block;
wherein film grain blocks of said pool are distributed over one or up to eight luminance intensity intervals.

2. The method according to claim 1 wherein selecting a film grain block further comprises accessing a look up table containing random numbers to obtain a random number.

3. The method according to claim 2 further comprising populating the look-up table in advance of film grain simulation with random numbers generated by a random number generator.

4. A method for creating blocks of pixels with film grain for random selection as a function of the average luminance value of the image block, comprising:

receiving film grain information that includes at least one parameter that specifies an attribute of the film grain to appear in the blocks;
creating blocks of random values selected from a previously established list of Gaussian random numbers;
obtaining transformed blocks of random numbers of said blocks of random values;
filtering the coefficients for the transformed blocks by at least one parameter in the received film grain information;
computing an inverse transform of the filtered set of coefficients for the blocks; scaling all the pixel values for each of the blocks as indicated by one parameter in the received film grain information; and
storing each of the blocks of film grain into a pool of film grain blocks such that a film grain block selection as a function of the average luminance value of the image block and a random number is enabled,
wherein film grain blocks of said pool are distributed over one or up to eight luminance intensity intervals.

5. The method according to claim 4 further comprising performing integer approximation of a Discrete Cosine Transform (OCT) and the Inverse Discrete Cosine Transform (IDCT) to reduce complexity.

6. The method according to claim 4 further comprising scaling top and bottom edges of the film grain blocks to hide block edges.

7. The method according to claim 4 wherein receiving the film grain information further comprises the step of decoding a Supplemental Enhancement Information message containing the at least one parameter.

8. Apparatus for simulating film grain in an image block, comprising:

means for computing the average of the pixel luminance values within the block; means for selecting a film grain block from among a pool of previously established blocks containing film grain, wherein selection is performed as a function of the average luminance value of the image block and a random number; and
means for blending each pixel in the selected film grain block with a corresponding pixel in the image block;
wherein film grain blocks of said pool are distributed over one or up to eight luminance intensity intervals.

9. The apparatus according to claim 8 wherein the means for selecting a film grain block comprises a look up table containing random numbers.

10. The apparatus according to claim 9 where the look-up table is populated in advance of film grain simulation with random numbers generated by a random number generator.

11. An apparatus for creating a block of pixels with film grain, for random selection as a function of the average luminance value of the image block and a random number, comprising:

means for receiving film grain information that includes at least one parameter that specifies an attribute of the film grain to appear in the block;
means for creating a block of random values selected from a previously established list of Gaussian random numbers; means for computing a Discrete Cosine Transform of the block of random numbers; means for filtering coefficients resulting from the Discrete Cosine Transform by at least one parameter in the received film grain information;
means for computing an Inverse Discrete Cosine Transform of the filtered set of coefficients;
means for scaling all the pixel values in the block as indicated by one parameter in the received film grain information; and
means for storing the created block of film grain into a pool of film grain blocks such that a film grain block selection as a function of the average luminance value of the image block and a random number is enabled;
wherein film grain blocks of said pool are distributed over one or up to eight luminance intensity intervals.

12. The apparatus according to claim 11 further comprising means for performing an integer approximation of a Discrete Cosine Transform (OCT) and the Inverse Discrete Cosine Transform (IDCT) to reduce complexity.

13. The apparatus according to claim 11 further comprising the means for scaling top and bottom edges of the created film grain block to hide block edges.

14. The apparatus according to claim 11 wherein means for receiving the film grain information further comprises means for decoding a Supplemental Enhancement Information message containing the at least one parameter.

15. A computer program product comprising computer readable instructions loadable into the memory of a computer and for causing the computer to perform the steps of any of claims 1-7.

Patentansprüche

1. Verfahren zum Simulieren von Filmkörnung in einem Bildblock, umfassend:

Berechnen des Mittelwerts der Pixel-Leuchtdichtewerte innerhalb des Bildblocks;
Auswählen eines Filmkörnungsblocks aus einem Pool von zuvor festgelegten Blöcken, die Filmkörnung enthalten, wobei die Auswahl in Abhängigkeit vom durchschnittlichen Leuchtdichtewert des Bildblocks und einer Zufallszahl durchgeführt wird; und
Mischen von jedem Pixel in dem ausgewählten Filmkörnungsblocks mit einem entsprechenden Pixel in dem Bildblock.
wobei Filmkörnungsblöcke des Pools über ein oder bis zu acht Leuchtdichteintervalle verteilt sind.

2. Verfahren nach Anspruch 1, wobei das Auswählen eines Filmkörnungsblocks ferner den Zugriff auf eine Nachschlagetabelle mit Zufallszahlen umfasst, um eine Zufallszahl zu erhalten.

3. Verfahren nach Anspruch 2, ferner umfassend das Füllen der Nachschlagetabelle vor der Filmkörnungssimulation mit Zufallszahlen, die von einem Zufallszahlengenerator erzeugt werden.

4. Verfahren zum Erzeugen von Pixelblöcken mit Filmkörnung zur zufälligen Auswahl als Funktion des durchschnittlichen Helligkeitswertes des Bildblocks, umfassend:

Empfangen von Filmkörnungsinformationen, die mindestens einen Parameter beinhalten, der ein Attribut der Filmkörnung angibt, das in den Blöcken erscheinen soll;
Erstellen von Blöcken von Zufallswerten, die aus einer zuvor erstellten Liste von Gaußschen Zufallszahlen ausgewählt wurden;
Erhalten von transformierten Blöcken von Zufallszahlen der Blöcke von Zufallswerten;
Filtern der Koeffizienten für die transformierten Blöcke durch mindestens einen Parameter in den empfangenen Filmkörnungsinformationen; Berechnen einer inversen Transformation des gefilterten Satzes von Koeffizienten für die Blöcke; Skalieren aller Pixelwerte für jeden der Blöcke, wie durch einen Parameter in der empfangenen

Filmkörnungsinformation angegeben; und
Speichern jedes der Filmkörnungsblöcke in einem Pool von Filmkörnungsblöcken, so dass eine Filmkörnungsblockauswahl als Funktion des durchschnittlichen Helligkeitswertes des Bildblocks und einer Zufallszahl aktiviert ist,
wobei Filmkörnungsblöcke des Pools über ein oder bis zu acht Leuchtdichteintervalle verteilt sind.

5. Verfahren nach Anspruch 4, ferner umfassend das Durchführen einer ganzzahligen Approximation einer diskreten Cosinustransformation (OCT) und der inversen diskreten Cosinustransformation (IDCT), um die Komplexität zu reduzieren.

6. Verfahren nach Anspruch 4, ferner umfassend das Skalieren der Ober- und Unterkanten der Filmkörnungsblöcke, um Blockkanten zu verbergen.

7. Verfahren nach Anspruch 4, wobei das Empfangen der Filmkörnungsinformationen ferner den Schritt des Dekodierens einer Nachricht über zusätzliche Verbesserungsinformationen, die den mindestens einen Parameter enthält, umfasst.

8. Vorrichtung zum Simulieren von Filmkörnung in einem Bildblock, umfassend:

Mittel zum Berechnen des Mittelwerts der Pixel-Leuchtdichtewerte innerhalb des Blocks; Mittel zum Auswählen eines Filmkörnungsblocks aus einem Pool von zuvor festgelegten Blöcken, die Filmkörnung enthalten, wobei die Auswahl in Abhängigkeit vom Mittelwert der Leuchtdichte des Bildblocks und einer Zufallszahl durchgeführt wird; und
Mittel zum Mischen jedes Pixels in dem ausgewählten Filmkörnungsblock mit einem entsprechenden Pixel in dem Bildblock;
wobei Filmkörnungsblöcke des Pools über ein oder bis zu acht Leuchtdichteintervalle verteilt sind.

9. Vorrichtung nach Anspruch 8, wobei das Mittel zum Auswählen eines Filmkörnungsblocks eine Nachschlagetabelle mit Zufallszahlen umfasst.

10. Vorrichtung nach Anspruch 9, wobei die Nachschlagetabelle vor der Filmkörnungssimulation mit Zufallszahlen gefüllt wird, die von einem Zufallszahlengenerator erzeugt werden.

11. Vorrichtung zum Erzeugen eines Pixelblocks mit Filmkörnung zur zufälligen Auswahl als Funktion des durchschnittlichen Helligkeitswertes des Bildblocks und einer Zufallszahl, umfassend:

Mittel zum Empfangen von Filmkörnungsinformationen, die mindestens einen Parameter beinhalten, der ein Attribut der Filmkörnung angibt, das in dem Block erscheinen soll;
Mittel zum Erzeugen eines Blocks von Zufallswerten, ausgewählt aus einer zuvor festgelegten Liste von Gaußschen Zufallszahlen; Mittel zum Berechnen einer diskreten Cosinustransformation des Blocks von Zufallszahlen; Mittel zum Filtern von Koeffizienten, die sich aus der diskreten Cosinustransformation ergeben, durch mindestens einen Parameter in der empfangenen Filmkörnungsinformation; Mittel zum Berechnen einer inversen diskreten Cosinustransformation des gefilterten Koeffizientensatzes; Mittel zum Skalieren aller Pixelwerte in dem Block, wie durch einen Parameter in der empfangenen Filmkörnungsinformation angezeigt; und
Mittel zum Speichern des erzeugten Filmkörnungsblocks in einem Pool von Filmkörnungsblöcken, so dass eine Filmkörnungsblockauswahl in Abhängigkeit vom durchschnittlichen Leuchtdichtewert des Bildblocks und einer Zufallszahl aktiviert wird;
wobei Filmkörnungsblöcke des Pools über ein oder bis zu acht Leuchtdichteintervalle verteilt sind.

12. Vorrichtung nach Anspruch 11, ferner umfassend Mittel zum Durchführen einer ganzzahligen Approximation einer diskreten Cosinustransformation (OCT) und der inversen diskreten Cosinustransformation (IDCT), um die Komplexität zu reduzieren.

13. Vorrichtung nach Anspruch 11, ferner umfassend die Mittel zum Skalieren der Ober- und Unterkanten des erzeugten Filmkörnungsblocks, um Blockkanten zu verbergen.

14. Vorrichtung nach Anspruch 11, wobei Mittel zum Empfangen der Filmkörnungsinformationen ferner Mittel zum Dekodieren einer Nachricht über eine ergänzende Verbesserungsinformation umfassen, die den mindestens einen

Parameter enthält.

15. Computerprogrammprodukt, umfassend computerlesbare Anweisungen, die in den Speicher eines Computers geladen werden können und die den Computer veranlassen, die Schritte nach einem der Ansprüche 1-7 auszuführen.

Revendications

1. Procédé de simulation de grain de film dans un bloc d'image comprenant : le calcul de la moyenne des valeurs de luminance de pixel dans le bloc d'image ; la sélection d'un bloc de grain de film parmi un pool de blocs établis antérieurement contenant un grain de film où la sélection est effectuée en fonction de la valeur de luminance moyenne du bloc d'image et d'un nombre aléatoire ; et
le mélange de chaque pixel dans le bloc de grain de film sélectionné avec un pixel correspondant dans le bloc d'image ;
dans lequel les blocs de grain de film dudit pool sont répartis sur un ou jusqu'à huit intervalles d'intensité de luminance.

2. Procédé selon la revendication 1, dans lequel la sélection d'un bloc de grain de film comprend en outre l'accès à une table de recherche contenant des nombres aléatoires pour obtenir un nombre aléatoire.

3. Procédé selon la revendication 2, comprenant en outre le remplissage de la table de recherche avant la simulation de grain de film avec des nombres aléatoires générés par un générateur de nombres aléatoires.

4. Procédé de création de blocs de pixels avec un grain de film pour une sélection aléatoire en fonction de la valeur de luminance moyenne du bloc d'image, comprenant :

la réception d'informations de grain de film qui incluent au moins un paramètre spécifiant un attribut du grain de film qui apparaîtra dans les blocs ;
la création de blocs de valeurs aléatoires sélectionnées dans une liste de nombres aléatoires gaussiens établie antérieurement ;
l'obtention de blocs transformés de nombres aléatoires desdits blocs de valeurs aléatoires ;
le filtrage des coefficients pour les blocs transformés selon au moins un paramètre dans les informations de grain de film reçues ; le calcul d'une transformée inverse de l'ensemble de coefficients filtré pour les blocs ; la mise à l'échelle de toutes les valeurs de pixel pour chacun des blocs comme indiqué par un paramètre dans les informations de grain de film reçues ; et
le stockage de chacun des blocs de grain de film dans un pool de blocs de grain de film de sorte à permettre une sélection de blocs de grain de film en fonction de la valeur de luminance moyenne du bloc d'image et d'un nombre aléatoire,
dans lequel les blocs de grain de film dudit pool sont répartis sur un ou jusqu'à huit intervalles d'intensité de luminance.

5. Procédé selon la revendication 4, comprenant en outre la mise en oeuvre d'une approximation en nombres entiers d'une transformée en cosinus discrète (DCT) et de la transformée en cosinus discrète inverse (IDCT) pour réduire la complexité.

6. Procédé selon la revendication 4, comprenant en outre la mise à l'échelle des bords supérieur et inférieur des blocs de grain de film pour masquer les bords de blocs.

7. Procédé selon la revendication 4, dans lequel la réception des informations de grain de film comprend en outre l'étape de décodage d'un message d'informations d'amélioration complémentaires contenant l'au moins un paramètre.

8. Appareil de simulation de grain de film dans un bloc d'image, comprenant :

un moyen pour calculer la moyenne des valeurs de luminance de pixel dans le bloc d'image ; un moyen pour sélectionner un bloc de grain de film parmi un pool de blocs établis antérieurement contenant un grain de film, où la sélection est effectuée en fonction de la valeur de luminance moyenne du bloc d'image et d'un nombre aléatoire ; et
un moyen pour mélanger chaque pixel dans le bloc de grain de film sélectionné avec un pixel correspondant

dans le bloc d'image ;
dans lequel les blocs de grain de film dudit pool sont répartis sur un ou jusqu'à huit intervalles d'intensité de luminance.

9. Appareil selon la revendication 8, dans lequel le moyen pour sélectionner un bloc de grain de film comprend une table de recherche contenant des nombres aléatoires.

10. Appareil selon la revendication 9, où la table de recherche est remplie avant la simulation de grain de film avec des nombres aléatoires générés par un générateur de nombres aléatoires.

11. Appareil de création d'un bloc de pixels avec un grain de film pour une sélection aléatoire en fonction de la valeur de luminance moyenne du bloc d'image et d'un nombre aléatoire, comprenant :

un moyen pour recevoir des informations de grain de film qui incluent au moins un paramètre spécifiant un attribut du grain de film qui apparaîtra dans le bloc ;
un moyen pour créer un bloc de valeurs aléatoires sélectionnées dans une liste de nombres aléatoires gaussiens établie antérieurement ; un moyen pour calculer une transformée en cosinus discrète du bloc de nombres aléatoires ; un moyen pour filtrer des coefficients résultant de la transformée en cosinus discrète selon au moins un paramètre dans les informations de grain de film reçues ;
un moyen pour calculer une transformée en cosinus discrète inverse de l'ensemble de coefficients filtré ;
un moyen pour mettre à l'échelle toutes les valeurs de pixel dans le bloc comme indiqué par un paramètre dans les informations de grain de film reçues ; et
un moyen pour stocker le bloc de grain de film créé dans un pool de blocs de grain de film de sorte à permettre une sélection de blocs de grain de film en fonction de la valeur de luminance moyenne du bloc d'image et d'un nombre aléatoire ;
dans lequel les blocs de grain de film dudit pool sont répartis sur un ou jusqu'à huit intervalles d'intensité de luminance.

12. Appareil selon la revendication 11, comprenant en outre un moyen pour mettre en oeuvre une approximation en nombres entiers d'une transformée en cosinus discrète (DCT) et la transformée en cosinus discrète inverse (IDCT) pour réduire la complexité.

13. Appareil selon la revendication 11, comprenant en outre le moyen pour mettre à l'échelle les bords supérieur et inférieur du bloc de grain de film créé pour masquer les bords de blocs.

14. Appareil selon la revendication 11, dans lequel le moyen de réception des informations de grain de film comprend en outre un moyen de décodage d'un message d'informations d'amélioration complémentaires contenant l'au moins un paramètre.

15. Programme informatique comprenant des instructions lisibles sur ordinateur pouvant être chargées dans la mémoire d'un ordinateur et indiquant à l'ordinateur de mettre en oeuvre les étapes selon l'une quelconque des revendications 1 à 7.

FIG. 1

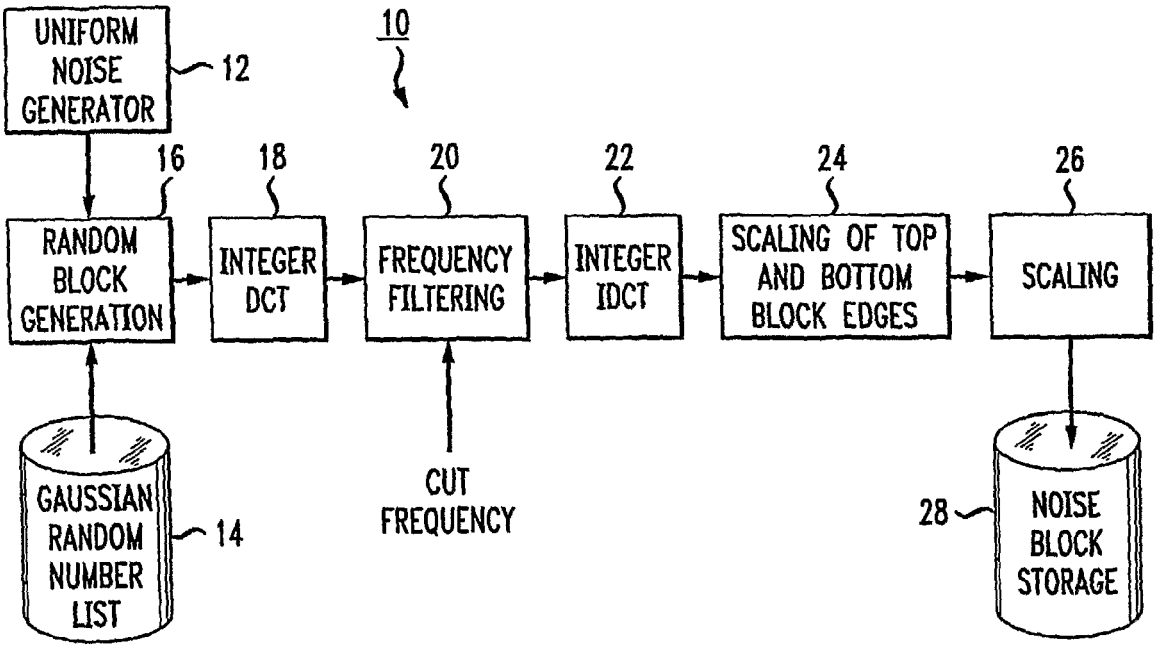
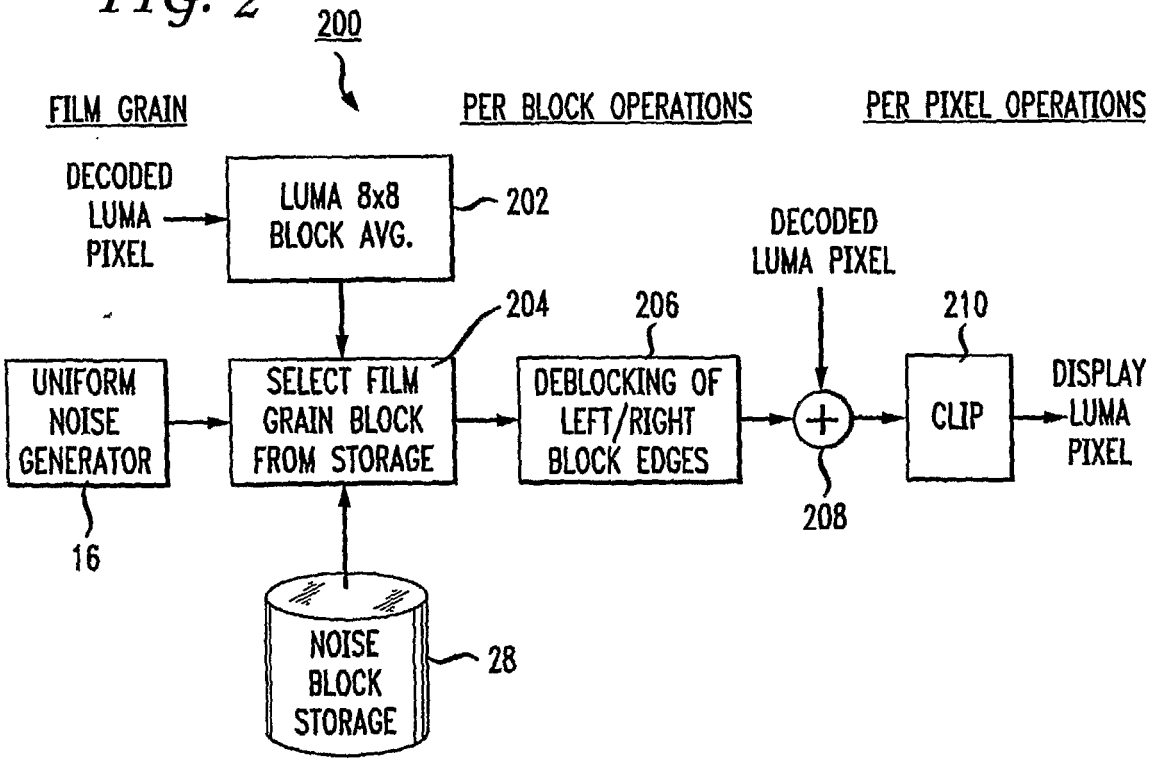

UNIFORM NOISE GENERATOR
12
10
16
18
20
22
24
26
RANDOM BLOCK GENERATION
INTEGER DCT
FREQUENCY FILTERING
INTEGER IDCT
SCALING OF TOP AND BOTTOM BLOCK EDGES
SCALING
GAUSSIAN RANDOM NUMBER LIST
14
CUT FREQUENCY
28
NOISE BLOCK STORAGE

FIG. 2


200
FILM GRAIN
PER BLOCK OPERATIONS
PER PIXEL OPERATIONS
DECODED LUMA PIXEL
LUMA 8x8 BLOCK AVG.
202
DECODED LUMA PIXEL
204
206
210
UNIFORM NOISE GENERATOR
SELECT FILM GRAIN BLOCK FROM STORAGE
DEBLOCKING OF LEFT/RIGHT BLOCK EDGES
CLIP
DISPLAY LUMA PIXEL
16
208
NOISE BLOCK STORAGE
28

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 51102603 P **[0001]**
- WO 9722204 A, PRZYBORSKI, GLENN, B; GIBSON, ROBERT, F; HARN, JOHN, H; HUCKE, LLOYD **[0007]**
- WO 19970619 A **[0007]**
- US 2003206662 A1 **[0007]**

Non-patent literature cited in the description

- **CHRISTINA GOMILA.** SEI message for film grain encoding: syntax and results. *JVT OF ISO IEC MPEG AND ITU-T VCEG JVT-I013 REVISION 2,* 02 September 2003 **[0010]**